

General

Guideline Title

ACR Appropriateness Criteria® suspected physical abuse—child.

Bibliographic Source(s)

Wootton-Gorges SL, Soares BP, Alazraki AL, Anupindi SA, Blount JP, Booth TN, Dempsey ME, Falcone RA Jr, Hayes LL, Kulkarni AV, Partap S, Rigsby CK, Ryan ME, Safdar NM, Trout AT, Widmann RF, Karmazyn BK, Palasis S, Expert Panel on Pediatric Imaging. ACR Appropriateness Criteria® suspected physical abuse—child. Reston (VA): American College of Radiology (ACR); 2016. 15 p. [85 references]

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Meyer JS, Coley BD, Karmazyn B, Binkovitz LA, Dempsey-Robertson ME, Dillman JR, Dory CE, Garber M, Hayes LL, Keller MS, Kulkarni AV, Milla SS, Myseros JS, Paidas C, Widmann RF, Raske ME, Rigsby CK, Strouse PJ, Wootton-Gorges SL, Expert Panel on Pediatric Imaging. ACR Appropriateness Criteria® suspected physical abuse -- child. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 9 p. [50 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Clinical Condition: Suspected Physical Abuse—Child

Variant 1: Suspected physical abuse. Child ≤24 months of age. Neurological or visceral injuries not clinically suspected. Initial imaging evaluation.

Radiologic Procedure	Rating	Comments	RRL*
X-ray skeletal survey	9		⊕⊕⊕⊕
MRI head without IV contrast	6		O
CT head without IV contrast	5		⊕⊕⊕⊕
Tc-99m bone scan whole body	4	This procedure is used as a problem-solving study rather than first-line.	⊕⊕⊕⊕⊕
Rating Scale: 1 2 3 Usually not appropriate; 4 5 6 May be appropriate; 7 8 9 Usually appropriate			*Relative

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	2		○
CT head with IV contrast	1		☼☼☼
CT head without and with IV contrast	1		☼☼☼☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Suspected physical abuse. Child >24 months of age. Neurological or visceral injuries not clinically suspected. Initial imaging evaluation.

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
CT head without IV contrast	6		☼☼☼
X-ray skeletal survey	5	Consider this procedure in children unable to verbalize location(s) of pain.	☼☼☼
MRI head without IV contrast	5		○
Tc-99m bone scan whole body	4	This procedure is used as a problem-solving study rather than first-line.	☼☼☼☼
MRI head without and with IV contrast	2		○
CT head with IV contrast	1		☼☼☼
CT head without and with IV contrast	1		☼☼☼☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Child with one or more of the following: neurologic signs or symptoms, apnea, complex skull fracture, other fractures, or injuries highly suspicious for child abuse. Initial imaging evaluation.

Radiologic Procedure	Rating	Comments	RRL*
X-ray skeletal survey	9		☼☼☼
CT head without IV contrast	9	Use this procedure in the emergent setting.	☼☼☼
MRI head without IV contrast	8	This procedure typically performed in the nonemergent setting.	○
MRI cervical spine without IV contrast	8	Consider this procedure at the time of MRI brain imaging.	○
MRI complete spine without IV contrast	5		○
Tc-99m bone scan whole body	5	This procedure is used as a problem-solving study rather than first-line.	☼☼☼☼
MRI head without and with IV contrast	3		○
MRI cervical spine without and with IV contrast	2		○
MRI complete spine without and with IV contrast	2		○
CT head with IV contrast	1		☼☼☼
CT head without and with IV contrast	1		☼☼☼☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 4: Child. Suspected physical abuse. Suspected thoracic or abdominopelvic injuries (e.g., abdominal skin bruises, distension, tenderness, or elevated liver or pancreatic enzymes). Initial imaging evaluation.

Radiologic Procedure	Rating	Comments	RRL*
X-ray skeletal survey	9		☢☢☢
CT abdomen and pelvis with IV contrast	9		☢☢☢☢
CT chest with IV contrast	6	This procedure may be combined with CT abdomen/pelvis with IV contrast if there is concern for intrathoracic injury.	☢☢☢☢
CT head without IV contrast	6	Use this procedure in the emergent setting if there is suspicion for concurrent intracranial injury.	☢☢☢
MRI head without IV contrast	6	This procedure typically performed in the nonemergent setting.	O
Tc-99m bone scan whole body	4		☢☢☢☢
CT chest without IV contrast	3	This procedure may be useful in limited situations, such as rib fracture evaluation.	☢☢☢☢
MRI head without and with IV contrast	2		O
CT abdomen and pelvis without IV contrast	2		☢☢☢☢
CT abdomen and pelvis without and with IV contrast	1		☢☢☢☢☢
CT head with IV contrast	1		☢☢☢
CT head without and with IV contrast	1		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 5: Child ≤24 months of age. High suspicion for abuse. Negative initial skeletal survey. Follow-up imaging evaluation.

Radiologic Procedure	Rating	Comments	RRL*
X-ray skeletal survey	9	This procedure is a limited (or focused) survey for follow-up after 2 weeks.	☢☢☢
Tc-99m bone scan whole body	6	This procedure is used as a problem-solving study rather than first-line.	☢☢☢☢
CT chest without IV contrast	5		☢☢☢☢
MRI head without IV contrast	5	Neurological examination may be difficult in this age group.	O
CT head without IV contrast	4		☢☢☢
MRI head without and with IV contrast	2		O
CT head with IV contrast	1		☢☢☢
CT head without and with IV contrast	1		☢☢☢☢
CT chest with IV contrast	1		☢☢☢☢
CT chest without and with IV contrast	1		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

Based on reports to child and protective service agencies, an estimated 3.2 million children were investigated for maltreatment (neglect, emotional abuse, sexual abuse, and physical abuse) in the United States in 2013, and an estimated 679,000 (9.1/1000 children) were victims of abuse. The youngest children are most vulnerable; children in their first year of life had the highest rate of victimization at 23.1/1000. An estimated 1520 children died from abuse, with three-fourths of these under 3 years of age. However, the full extent of child abuse is not known because of underreporting.

Eighteen percent of maltreated children were physically abused by being hit, shaken, thrown, poisoned, burned, scalded, drowned, and/or suffocated. Physically abused children may present with neurological injuries, hollow viscus and solid-organ injuries, superficial and deep soft-tissue injuries, thermal injuries, and/or fractures. Fractures highly suggestive of physical abuse include rib fractures, classic metaphyseal lesions, those unsuspected or inconsistent with the history or age of the child, multiple fractures involving more than 1 skeletal area, and fractures of differing ages. In some children, physical examination and history may clearly indicate that physical abuse has occurred. In other children, however, the diagnosis of abuse is not so straightforward and requires clinical, laboratory, imaging, pathological, and forensic evaluation and usually relies on the findings of a multidisciplinary team that includes physicians, social workers, and legal authorities. Imaging often plays a major role in the detection and documentation of physical injury. The type and extent of imaging performed in a child who is a suspected victim of abuse depends on the child's age, signs, symptoms, and other social considerations, such as being the twin or sibling of a physically abused infant. Making the diagnosis of child abuse requires differentiation from anatomical and developmental variants and possible underlying metabolic and genetic conditions.

Overview of Imaging Modalities

X-ray Skeletal Survey

The radiographic skeletal survey is the primary imaging examination for detecting fractures. The skeletal survey should be composed of frontal and lateral views of the skull, lateral views of the cervical spine and thoracolumbosacral spine, and single frontal views of the long bones, hands, feet, chest, and abdomen. Oblique views of the ribs should be obtained to increase the accuracy of diagnosing rib fractures, which are strong positive predictors and may be the only skeletal manifestation of abuse.

The images should be obtained using high-detail imaging systems and coned to the specific area of interest for each of the body parts, with separate views of each arm, forearm, thigh, leg, hand, and foot to improve image quality and diagnostic accuracy (see Appendix 1 in the original guideline document). Fractures most often involve the long bones and ribs, with lesser involvement of the skull and clavicles and even less frequent involvement of the pelvis, spine, hands, and feet. It has therefore been questioned whether the radiation exposure outweighs the potential benefit of imaging the pelvis, spine, hands, and feet on initial skeletal survey. Although not part of American College of Radiology (ACR) or American Academy of Pediatrics guidelines, some add lateral radiographs of the long bones, which have been shown to increase detection of metaphyseal fractures by 50%. A repeat skeletal survey performed approximately 2 weeks after the initial examination can provide additional information on the presence and age of child abuse fractures in up to 12% of children and should be performed when abnormal or equivocal findings are found on the initial study and when abuse is suspected on clinical grounds. To limit radiation exposure, pelvis, spine, and skull radiographs can be omitted if no injury was initially seen in these regions. However, it is not possible to exactly date fractures by radiography.

Technetium-99 metastable (Tc-99m) Bone Scan Whole Body

In experienced hands, bone scintigraphy is a complementary/adjunctive examination for detecting bone injuries but is usually not considered an alternative to skeletal survey. It should be used when the radiographic skeletal survey is negative but clinical suspicion remains high and a search for further evidence of skeletal trauma is warranted. It may aid by detecting bony injury that is occult, equivocal, or subtle on plain radiographs, but it requires venipuncture and often requires sedation. In addition to standard images, the use of pinhole collimators and differential counts of the metaphyses may improve sensitivity. A bone scan is especially good for detecting periosteal reaction and rib, spine, pelvic, and acromion fractures. However, skull fractures and fractures near the growth plates, because of normally increased activity in the growth plate, may be difficult to appreciate. Bone scan is also not useful in dating of fractures, as the scan may be active for up to a year after injury.

CT Head without Contrast

Unenhanced computed tomography (CT) of the head is the examination of choice to evaluate children with suspected abusive head trauma (AHT). These include children who had skeletal survey for suspected child abuse, children with neurological changes, and children with facial injuries raising concern for abuse. Multiplanar reformations and 3-dimensional (3-D) volume rendering of the skull increase sensitivity for fracture and intracranial hemorrhage.

MRI Head without Contrast

Magnetic resonance imaging (MRI) is sensitive for the detection of small-volume extra-axial hemorrhage and for evolving parenchymal injury. In addition to standard sequences, diffusion-weighted imaging and susceptibility-weighted imaging increase sensitivity for detection of parenchymal ischemia, diffuse axonal injury, and microhemorrhage and can provide prognostic information in AHT. The addition of contrast-enhanced MRI sequences can be used in select cases to improve evaluation of extra-axial collections as it increases the sensitivity for the detection of membranes in subdural collections, a finding that indicates a chronic component. Care must be taken when attempting to date subdural collections, however, as the imaging appearance depends not just on the age of blood products but also on the potential presence of cerebrospinal fluid accumulation in the subdural space through an arachnoid laceration (hematohydruma). Thrombosis of bridging veins in the subdural space also suggest abusive trauma.

The MRI should include T1- and T2-weighted imaging as well as T2 FLAIR and T2* (gradient-echo or susceptibility-weighted imaging) sequences. Diffusion-weighted sequences are required to indicate whether acute cerebral injury is present. Susceptibility-weighted imaging may be useful in detection of blood products in the brain as well as retinal hemorrhages. MRI is a particularly good choice to image children at high risk for AHT in the nonemergent setting but is a lengthy scan often requiring sedation, so it is typically not utilized in the emergent setting.

MRI Spine

Recent evidence supports that spine injury is common in children with AHT. In recent retrospective studies, ligamentous injury at the craniocervical junction and spinal subdural hemorrhage (SDH) are reported in 36% to 78% and 44% to 63% of AHT cases, respectively. MRI of the cervical spine, including fat-suppressed fluid-sensitive sequences, a sagittal short tau inversion recovery or T2 fat-saturated sequence, should be performed in all cases where the skeletal survey demonstrates any fractures or when clinical concern for craniocervical junction or spinal injury is high. The prevalence of spine fracture is increased to almost 10% in the setting of a positive skeletal survey and is significantly associated with intracranial injury. The high incidence of cervical injuries in abused children with bilateral hypoxic-ischemic brain injuries suggests a causal relationship.

The value of routine screening of the whole spine in suspected AHT is still debated. In a subgroup of 38 children with AHT who underwent thoracolumbar spine imaging, 24 (63%) had thoracolumbar SDH, whereas only 1 of 70 patients with accidental trauma had spinal SDH in the same study. None of the children had spinal cord compression or long-term complications from the presence of the spinal SDH, and that imaging was performed mostly because of concern for thoracic or abdominal injury. Although not usually prompting change in management, detection of spinal SDH is significantly increased when imaging is extended through the thoracolumbar spine. The presence of thoracolumbar SDH does not imply direct trauma to the thoracolumbar spine and may be related to redistribution of blood products. Nevertheless, this finding has medicolegal implications as it may document otherwise undetected injury and may help distinguish between abusive and accidental injury.

CT Chest without Contrast

CT of the chest is more sensitive than chest radiography in detection of rib fractures; chest radiography defines only about 60% of the fractures that are detected by CT. Anterior and posterior fractures are better seen by CT, as are bilateral fractures. However, the need for sedation in noncooperative children makes this test a useful adjunct rather than a first-line test in the imaging workup of nonaccidental trauma (NAT). A reduced-dose chest CT may detect rib fractures in infants with high suspicion for NAT and a normal initial 4-view chest, with a submillisievert radiation dose equaling twice that of a 4-view chest. Multiplanar reformatted images may aid in rib fracture detection. In addition, chest CT may detect scapular and spine fractures not evident on skeletal survey.

CT Chest with Contrast

A CT scan of the chest with intravenous (IV) contrast is reserved for children with clinical suspicion of intrathoracic traumatic injury. IV contrast allows for detection of vascular injuries.

CT Abdomen and Pelvis with Contrast

CT of the abdomen and pelvis with IV contrast is utilized for children with suspected intra-abdominal and/or intrapelvic injury. Portal venous phase imaging is most helpful for detecting solid-organ injury. Delayed excretory-phase imaging may be useful in a few selected cases when imaging findings suggest disruption of the genitourinary tract. Noncontrast abdominal CT is not recommended. The need for oral contrast is at the discretion of the radiologist, and its use may be considered when there is concern for duodenal hematoma.

Discussion of Imaging Modalities by Variant

Variant 1: Suspected Physical Abuse. Child ≤ 24 Months of Age. Neurological or Visceral Injuries Not Clinically Suspected. Initial Imaging Evaluation

X-ray Skeletal Survey

Children <6 months of age with bruising raising the possibility of NAT have a high incidence of additional injuries. Radiographic skeletal surveys are the initial imaging modality of choice as fractures occur in up to 55% of physically abused children. The majority of skeletal surveys that are positive for fractures are performed in children <1 year of age, and 80% of abused children with fractures are <18 months of age. Thus, skeletal survey is recommended in all children <2 years of age in whom there is suspicion of abuse. Eleven percent to 20% of infants undergoing evaluation for abuse have an unsuspected fracture detected by skeletal survey. Fractures that are highly specific for NAT in the normal child include those involving the posterior ribs, classic metaphyseal lesions or epiphyseal separation injuries, and avulsive fractures of the acromion process. Rib fractures may be the only skeletal abnormality in about 30% of physically abused infants.

Highly suggestive skeletal injuries include fractures that are unsuspected or inconsistent with the provided history or age of the child, multiple fractures involving >1 skeletal area, fractures of differing ages, and a combination of skeletal and nonskeletal injuries. In addition, fractures of the radius, ulna, tibia, fibula, or femur that occur in children <1 year of age and midshaft or metaphyseal humeral fractures should be considered suspicious for abuse. The child's motor developmental level is a key discriminator for abuse in certain fractures. In particular, femoral fractures in a child who is not yet walking and unexplained humeral fractures in children <15 months of age should be considered suspicious for abuse. Multiple fractures in any location without overt trauma are strongly associated with abusive injury. Pediatric contacts of abused children may also need to be screened by skeletal survey, especially twins.

Tc-99m Bone Scan Whole Body

Bone scintigraphy is a complementary/adjunctive examination for detecting bone injuries but is usually not considered an alternative to skeletal survey. It should be used when the radiographic skeletal survey is negative but clinical suspicion remains high and search for further evidence of skeletal trauma is warranted. It may aid by detecting bony injury that is occult, equivocal, or subtle on plain radiographs, but it requires venipuncture and often requires sedation.

CT Head and MRI Head

There are varying opinions on how to image suspected abuse victims who show no evidence suggesting intracranial injury. Although skull radiographs may detect fractures associated with intracranial pathology, they do not provide adequate screening, since significant traumatic intracranial pathology may occur in the absence of skull fractures. Children, especially those <12 months of age, may have significant intracranial injury without signs or symptoms of head injury or retinal hemorrhage. Unenhanced CT of the head is the examination of choice for initial evaluation for intracranial injury in child abuse. MRI is a good choice to image children for abusive head injury in the nonemergent setting.

A study of abused children without clinical suspicion of intracranial injury showed that 11 (29%) of the 51 children had positive neuroimaging including subdural hematoma, epidural hematoma, or cerebral edema; most of them had negative skeletal surveys and no retinal hemorrhage. Eight of the 11 children were <12 months of age. In another prospective study of infants <6 months of age evaluated for possible physical abuse, the presence of apparently isolated bruises (seen in 146 children) at presentation correlated with new injury on neuroimaging in 40 children (27%). In yet another study, 37% of children <2 years of age with high-risk criteria (defined as rib fractures, multiple fractures, facial injury, or <6 months of age) and without overt signs of head injury who underwent head CT or MRI had occult head injury; nearly all with occult head injury were <1 year of age. Intracranial injury is also associated with spinal trauma seen on skeletal survey. Given these studies, clinicians should have a relatively low threshold for performing either CT (emergent setting and more sensitive for detection of nondisplaced fractures) or MRI of the head in children with suspected abuse.

In summary, there is no strong evidence to recommend universal screening with neuroimaging. However, clinicians should have low threshold for performing head CT or MRI in young children with suspected child abuse.

Variant 2: Suspected Physical Abuse. Child >24 Months of Age. Neurological or Visceral Injuries Not Clinically Suspected. Initial Imaging Evaluation

X-ray Area of Interest

Children >2 years of age are often able to verbalize the area(s) of injury or pain during clinical examination. Thus, initial imaging should focus on the areas of clinical concern.

X-ray Skeletal Survey

In children >2 years of age, performance of skeletal survey is usually not done but may be performed based on clinical findings and the need to document the presence or absence of injuries. In this older group of children, skeletal imaging should be strongly considered in a child who has unexplained craniocerebral or abdominal injuries or fractures that are suspicious for abuse. Multiple areas of fracture and unusual fractures should raise one's suspicion for child abuse; the common accidental fractures in children of this age group are distal humeral and distal radius/ulna after a short fall.

Tc-99m Bone Scan Whole Body

Bone scintigraphy is a complementary/adjunctive examination for detecting bone injuries. It may aid by detecting bony injury that is occult, equivocal, or subtle on plain radiographs, but the study requires venipuncture and often requires sedation.

CT Head and MRI Head

Unenhanced CT of the head is the examination of choice for acute evaluation for intracranial injury in child abuse. However, there is no strong evidence to recommend universal screening with neuroimaging in the absence of clinical suspicion for AHT. This is particularly true in older children where the neurological examination is typically more reliable, except for children with chronic disabilities.

MRI is a good choice to image children for abusive head injury in the nonemergent setting. MRI is useful in the detection of small-volume extra-axial hemorrhage and for evolving parenchymal injury. Diffusion-weighted imaging and susceptibility-weighted imaging increase the sensitivity for detection of parenchymal ischemia, diffuse axonal injury, and microhemorrhage. The addition of contrast-enhanced MRI sequences can be utilized in select cases to improve evaluation of extra-axial fluid collections.

Variant 3: Child with One or More of the Following: Neurologic Signs or Symptoms, Apnea, Complex Skull Fracture, Other Fractures, or Injuries Highly Suspicious for Child Abuse. Initial Imaging Evaluation

X-ray Skeletal Survey

The skeletal survey is the primary examination for detecting fractures. Fractures occur in up to 55% of physically abused children; 80% of abused children with fractures are <18 months of age. Thus, skeletal survey is recommended in all children <2 years of age in whom there is suspicion of abuse.

Tc-99m Bone Scan Whole Body

Bone scintigraphy is a complementary/adjunctive examination for detecting bone injuries. It may aid by detecting bony injury that is occult, equivocal, or subtle on plain radiographs. Skull fractures and fractures near the growth plates, however, may be difficult to appreciate.

CT Head

Although less frequent than skeletal injuries, most child abuse fatalities are the result of head trauma, and head injury due to child abuse is the principal cause of death in children <2 years of age. AHT is responsible for the majority of severe traumatic brain injury in children <2 years of age, with case fatality rates above 20%. Subdural hematoma is the most commonly seen intracranial abnormality (multiple, convexity, interhemispheric, posterior fossa). Additional craniocerebral injuries include cerebral contusion, epidural hematoma, cerebral edema, subarachnoid hemorrhage, and unilateral hypoxic/ischemic injury. Imaging the head in children with suspected abuse depends on the child's age and type of presentation.

In children with skull fractures or clinical signs and symptoms of intracranial injury, an immediate noncontrast CT scan of the head should be performed. Contrast administration for the head CT examination is not indicated. If the CT scan does not detect significant lesions that require rapid neurosurgical intervention and the clinical presentation warrants further assessment, an MRI scan of the head should be performed.

MRI Head

Additional diagnostic information will be found on MRI over CT in about 25% of patients, and MRI can also contribute to prognosis. In a child with an abnormal CT, additional assessment with MRI should be considered to further assess the extent of post-traumatic injury. Care should be taken in trying to determine the age of subdural hematomas by CT or MRI. Although hyperdense blood products can be considered acute, collections of low or intermediate density do not indicate necessarily chronic blood products, as lacerations of the arachnoid may result in subdural hygromas or hematomas in the early or late post-traumatic periods. MR venography utilizing unenhanced 2-dimensional time-of-flight technique can be used to assess patency of the dural venous sinuses and deep venous system.

Neuroimaging should not be performed as a screening examination in all children but should be used for further evaluation of all abnormal initial examinations and in cases of clinical suspicion. The clinician should have a relatively low threshold for performing either CT (emergent setting) or MRI of the head (nonemergent setting), especially in children under 1 year of age.

MRI Cervical Spine

MRI of the cervical spine should be strongly considered at the time of MRI brain imaging, as unsuspected spinal injuries may be demonstrated in >36% of cases. Cervical spine injury, particularly at the craniocervical junction, is highly associated with bilateral hypoxic-ischemic injury. Most cervical spine injury detected by MRI in abused infants is ligamentous.

MRI Complete Spine

MRI of the entire spine may show thoracolumbar SDH, most commonly from redistribution of blood products; however, it rarely results in cord compression or alters clinical management. An MRI of the total spine should be reserved for cases where the distinction between abusive and accidental trauma is not clear, since thoracolumbar SDH is more commonly seen with abusive trauma.

Variant 4: Child. Suspected Physical Abuse. Suspected Thoracic or Abdominopelvic Injuries (e.g., Abdominal Skin Bruises, Distension, Tenderness, or Elevated Liver or Pancreatic Enzymes). Initial Imaging Evaluation

X-ray Skeletal Survey

As most children with thoracic or abdominopelvic injury from child abuse have polytrauma, skeletal survey is recommended in all children 24 months of age or younger and should be considered in older children.

Tc-99m Bone Scan Whole Body

Bone scintigraphy is a complementary/adjunctive examination for detecting bone injuries. It may aid by detecting bony injury that is occult, equivocal, or subtle on plain radiographs.

CT Head and MRI Head

CT or MRI of the head should also be performed in children with neurologic symptoms or risk factors for intracranial injuries (see Variant 3).

CT of the Abdomen and Pelvis

Nonskeletal injuries to the chest, abdomen, and pelvis can occur as the result of child abuse. Child abuse should be considered in any child with thoracoabdominal injuries that are not consistent with the provided history.

Up to 10% of abused children have intra-abdominal injury; 15% of children aged 0 to 4 years hospitalized for abdominal injury are victims of child abuse. Victims of nonaccidental abdominal trauma tend to be younger and have a more delayed presentation than those who experience accidental trauma. Clinical findings of abdominal pain, abdominal distension, vomiting, abdominal wall bruising, and hypoactive or absent bowel sounds may suggest intra-abdominal injury. Abnormal liver transaminases and pancreatic enzymes may be seen with occult abdominal trauma.

One series suggested that nearly half of abused children with abdominal injury require surgical intervention. In addition, independent of concomitant injury, blunt trauma due to child abuse is associated with a 6-fold increase in odds of death compared to children whose injuries resulted from accidental trauma. Nonskeletal abdominopelvic injuries include pancreatitis, pancreatic pseudocysts, and lacerations and contusions of the liver, adrenal gland, spleen, kidneys, and bowel (especially duodenum). Bowel injuries and pancreatic injuries are seen disproportionately more often in child abuse compared to accidental trauma. Contrast-enhanced CT of the abdomen is indicated in acute evaluation of the child with suspected abdominopelvic injuries. The use of ultrasound in the acute setting is limited, as both focused abdominal scan in trauma and standard abdominopelvic ultrasound are less sensitive than CT in detection of hemoperitoneum and solid-organ injuries. Noncontrast CT of the abdomen is not adequately sensitive in detection of intrathoracic or intra-abdominal trauma. Routine CT scan screening for abdominal or chest injury is not recommended.

CT of the Chest

Injuries to the chest (other than the ribs) are uncommon and include hemopericardium, cardiac contusions and lacerations, pleural effusion, and lung contusions. Contrast-enhanced CT of the chest is indicated in acute evaluation of the child with these types of suspected nonskeletal intrathoracic injury; noncontrast CT of the chest is not adequately sensitive. Routine CT scan screening for chest injury is not recommended.

Variant 5: Child \leq 24 Months of Age. High Suspicion for Abuse. Negative Initial Skeletal Survey. Follow-up Imaging Evaluation

X-ray Skeletal Survey

Additional imaging may be useful in children suspected of nonaccidental injury whose initial skeletal survey is negative. A negative initial skeletal survey has a true negative rate of about 90%, so with high clinical suspicion, it is very appropriate to perform further imaging such as follow-up skeletal survey, bone scan, and/or noncontrast low-dose CT of the chest.

In children <24 months of age, a repeat skeletal survey performed approximately 2 weeks after the initial examination can detect fractures not seen on initial skeletal survey, can clarify equivocal findings, and can provide information on the age of child abuse fractures. Nine to 12% of infants have healing fractures on follow-up survey after a negative initial survey, and up to one-third of follow-up surveys yield new information. Half to

three-fourths of these newly detected fractures are rib fractures; classic metaphyseal lesions are the second most common. As such, many authors have suggested a more limited follow-up skeletal survey, as described above. However, it is not possible to exactly date fractures by radiography.

Tc-99m Bone Scan Whole Body

In selected cases, when it is not possible to wait 2 weeks for a follow-up skeletal survey radiograph, a bone scan can be considered. Bone scan is sensitive in detecting radiographically occult fractures. It is particularly useful in detection of fractures of the ribs, scapula, spine, and pelvis. It is not sensitive, however, in the detection of skull fractures. Metaphyseal injury may be difficult to see because of the adjacent normal metabolically active physis. Radiation exposure is higher than a skeletal survey. If used in follow-up, radiographs of areas of abnormal uptake should also be performed.

CT Chest

Low-dose noncontrast CT of the chest also offers a time advantage over repeat skeletal survey. It is useful in the detection of rib, scapula, and thoracic spine fractures not seen on skeletal survey. Anterior and posterior rib fractures are detected more often by CT than by skeletal survey. Fractures may also be dated as acute, subacute, or chronic. It would not replace contrast-enhanced chest CT in initial evaluation of nonskeletal thoracic injuries, such as hemopericardium, cardiac contusions and lacerations, pleural effusion, and lung contusions.

CT Head and MRI Head

Follow-up neuroimaging is usually not indicated in the setting of a negative skeletal survey and absence of clinical suspicion of AHT. If there is suspicion for injury after the initial evaluation, neuroimaging should be considered. Noncontrast CT is useful in the evaluation of healing skull fractures, whereas MRI is the method of choice to evaluate the intracranial compartment.

Summary of Recommendations

- The appropriate imaging of pediatric patients being evaluated for suspected physical abuse depends upon the age of the child, the presence of neurological signs and symptoms, and evidence of visceral thoracic or abdominopelvic injuries.
- A skeletal survey is indicated in the initial imaging evaluation of a child 24 months of age or younger. In older children, it is usually appropriate to target imaging to the area(s) of suspected injury.
- Skeletal survey and CT head without contrast are indicated in the emergent/initial imaging evaluation of a child with neurologic signs and symptoms, complex skull fracture, apnea, multiple fractures, spine trauma, or facial injury. These examinations are not indicated for general screening.
- MRI head may provide additional diagnostic information to head CT in about 25% of children.
- MRI of the cervical spine should be considered at the time of head MRI, as unsuspected injury (usually ligamentous) may be present in over 33% of children with intracranial injury.
- Skeletal survey and CT chest/abdomen/pelvis with IV contrast are indicated if there are signs or symptoms of intrathoracic or intra-abdominal visceral injury (abdominal pain/distension/bruising, abnormal liver, or pancreatic enzymes, etc.).
- In children 24 months of age or younger with equivocal skeletal survey or with a high clinical suspicion for abuse and a negative initial skeletal survey, a repeat limited/focused skeletal survey performed at 2 weeks may add diagnostic information.

Abbreviations

- CT, computed tomography
- IV, intravenous
- MRI, magnetic resonance imaging
- Tc-99m, technetium-99 metastable

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
0	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3-3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv

Relative Radiation Level*	Adult Effective Dose Estimate Range 30-100 mSv	Pediatric Effective Dose Estimate Range 10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Suspected child physical abuse

Guideline Category

Diagnosis

Evaluation

Clinical Specialty

Emergency Medicine

Family Practice

Neurological Surgery

Neurology

Nuclear Medicine

Pediatrics

Radiology

Intended Users

Advanced Practice Nurses

Health Care Providers

Health Plans

Hospitals

Managed Care Organizations

Physician Assistants

Physicians

Students

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of imaging procedures for children suspected of being physically abused

Target Population

Children suspected of being physically abused

Interventions and Practices Considered

1. X-ray
 - Skeletal survey
 - Area of interest
2. Magnetic resonance imaging (MRI)
 - Head without intravenous (IV) contrast
 - Head without and with IV contrast
 - Cervical spine without IV contrast
 - Cervical spine without and with IV contrast
 - Complete spine without IV contrast
 - Complete spine without and with IV contrast
3. Computed tomography (CT)
 - Head without IV contrast
 - Head with IV contrast
 - Head without and with IV contrast
 - Abdomen and pelvis with IV contrast
 - Abdomen and pelvis without IV contrast
 - Abdomen and pelvis without and with IV contrast
 - Chest with IV contrast
 - Chest without IV contrast
 - Chest without and with IV contrast
4. Technetium (Tc)-99m bone scan, whole body

Major Outcomes Considered

- Utility of imaging procedures in the diagnosis and evaluation of suspected physical abuse in children
- Sensitivity, specificity, and accuracy of imaging procedures in the diagnosis and evaluation of suspected physical abuse in children

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Summary

Of the 50 citations in the original bibliography, 27 were retained in the final document.

A literature search was conducted in March 2015 to identify additional evidence published since the *ACR Appropriateness Criteria® Suspected Physical Abuse—Child* topic was finalized. Using the search strategy described in the literature search companion (see the "Availability of Companion Documents" field), 316 articles were found. Twenty-nine articles were added to the bibliography. The remaining articles were not used due to either poor study design, the articles were not relevant or generalizable to the topic, or the results were unclear or biased.

The author added 28 citations from bibliographies, Web sites, or books that were not found in the literature search, including 11 articles outside of the search date range.

One citation is a supporting document that was added by staff.

See also the American College of Radiology (ACR) Appropriateness Criteria® literature search process document (see the "Availability of Companion Documents" field) for further information.

Number of Source Documents

Of the 50 citations in the original bibliography, 27 were retained in the final document. The literature search conducted in March 2015 identified 29 articles that were added to the bibliography. The author added 28 citations from bibliographies, Web sites, or books that were not found in the literature search, including 11 articles outside of the search date range. One citation is a supporting document that was added by staff.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Definitions of Study Quality Categories

Category 1 - The study is well-designed and accounts for common biases.

Category 2 - The study is moderately well-designed and accounts for most common biases.

Category 3 - The study has important study design limitations.

Category 4 - The study or source is not useful as primary evidence. The article may not be a clinical study, the study design is invalid, or conclusions are based on expert consensus.

The study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);

Or

The study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;

Or

The study is an expert opinion or consensus document.

Category M - Meta-analysis studies are not rated for study quality using the study element method because the method is designed to evaluate individual studies only. An "M" for the study quality will indicate that the study quality has not been evaluated for the meta-analysis study.

Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Description of the Methods Used to Analyze the Evidence

The topic author assesses the literature then drafts or revises the narrative summarizing the evidence found in the literature. American College of Radiology (ACR) staff drafts an evidence table based on the analysis of the selected literature. These tables rate the study quality for each article included in the narrative.

The expert panel reviews the narrative, evidence table and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the variant table(s). Each individual panel member assigns a rating based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

Rating Appropriateness

The American College of Radiology (ACR) Appropriateness Criteria (AC) methodology is based on the RAND Appropriateness Method. The appropriateness ratings for each of the procedures or treatments included in the AC topics are determined using a modified Delphi method. A series of surveys are conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. The expert panel members review the evidence presented and assess the risks or harms of doing the procedure balanced with the benefits of performing the procedure. The direct or indirect costs of a procedure are not considered as a risk or harm when determining appropriateness. When the evidence for a specific topic and variant is uncertain or incomplete, expert opinion may supplement the available evidence or may be the sole source for assessing the appropriateness.

The appropriateness is represented on an ordinal scale that uses integers from 1 to 9 grouped into three categories: 1, 2, or 3 are in the category "usually not appropriate" where the harms of doing the procedure outweigh the benefits; and 7, 8, or 9 are in the category "usually appropriate" where the benefits of doing a procedure outweigh the harms or risks. The middle category, designated "may be appropriate," is represented by 4, 5, or 6 on the scale. The middle category is when the risks and benefits are equivocal or unclear, the dispersion of the individual ratings from the group median rating is too large (i.e., disagreement), the evidence is contradictory or unclear, or there are special circumstances or subpopulations which could influence the risks or benefits that are embedded in the variant.

The ratings assigned by each panel member are presented in a table displaying the frequency distribution of the ratings without identifying which members provided any particular rating. To determine the panel's recommendation, the rating category that contains the median group rating without disagreement is selected. This may be determined after either the first or second rating round. If there is disagreement after the second rating round, the recommendation is "May be appropriate."

This modified Delphi method enables each panelist to articulate his or her individual interpretations of the evidence or expert opinion without excessive influence from fellow panelists in a simple, standardized, and economical process. For additional information on the ratings process see the [Rating Round Information](#) document.

Additional methodology documents, including a more detailed explanation of the complete topic development process and all ACR AC topics can be found on the [ACR Web site](#) (see also the "Availability of Companion Documents" field).

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current medical evidence literature and the application of the RAND/UCLA appropriateness method and expert panel consensus.

Summary of Evidence

Of the 85 references cited in the *ACR Appropriateness Criteria® Suspected Physical Abuse—Child* document, all of them are categorized as diagnostic references including 3 good-quality studies, and 19 quality studies that may have design limitations. There are 61 references that may not be useful as primary evidence. There are 2 references that are meta-analysis studies.

Although there are references that report on studies with design limitations, 2 good-quality studies provide good evidence.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

Selection of appropriate radiologic imaging procedures for evaluation of children suspected of physical abuse

Potential Harms

It has been questioned whether the radiation exposure outweighs the potential benefit of imaging the pelvis, spine, hands, and feet on initial X-ray skeletal survey.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the American College of Radiology (ACR) Appropriateness Criteria® Radiation Dose Assessment Introduction document (see the "Availability of Companion Documents" field).

Qualifying Statements

Qualifying Statements

- The American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.
- ACR seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply society endorsement of the final document.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Wootton-Gorges SL, Soares BP, Alazraki AL, Anupindi SA, Blount JP, Booth TN, Dempsey ME, Falcone RA Jr, Hayes LL, Kulkarni AV, Partap S, Rigsby CK, Ryan ME, Safdar NM, Trout AT, Widmann RF, Karmazyn BK, Palasis S, Expert Panel on Pediatric Imaging. ACR Appropriateness Criteria® suspected physical abuse—child. Reston (VA): American College of Radiology (ACR); 2016. 15 p. [85 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2016

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

Source(s) of Funding

American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Pediatric Imaging

Composition of Group That Authored the Guideline

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Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Meyer JS, Coley BD, Karmazyn B, Binkovitz LA, Dempsey-Robertson ME, Dillman JR, Dory CE, Garber M, Hayes LL, Keller MS, Kulkarni AV, Milla SS, Myseros JS, Paidas C, Widmann RF, Raske ME, Rigsby CK, Strouse PJ, Wootton-Gorges SL, Expert Panel on Pediatric Imaging. ACR Appropriateness Criteria® suspected physical abuse -- child. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 9 p. [50 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Available from the [American College of Radiology \(ACR\) Web site](#) .

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2015 Oct. 3 p. Available from the [American College of Radiology \(ACR\) Web site](#) .
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 2015 Feb. 1 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria®. Evidence table development. Reston (VA): American College of Radiology; 2015 Nov. 5 p. Available

from the [ACR Web site](#) .

- ACR Appropriateness Criteria®. Topic development process. Reston (VA): American College of Radiology; 2015 Nov. 2 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria®. Rating round information. Reston (VA): American College of Radiology; 2015 Apr. 5 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2016. 4 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria®. Manual on contrast media. Reston (VA): American College of Radiology; 2016. 128 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 2016 May. 2 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria® suspected physical abuse—child. Evidence table. Reston (VA): American College of Radiology; 2016. 28 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria® suspected physical abuse—child. Literature search. Reston (VA): American College of Radiology; 2016. 1 p. Available from the [ACR Web site](#) .

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI on March 30, 2006. This summary was updated by ECRI Institute on December 13, 2010. This summary was updated by ECRI Institute on November 14, 2012. This summary was updated by ECRI Institute on March 23, 2017.

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